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Navigation Canals of Europe

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NAVIGATION CANALS

OF

EUROPE

BY

LEO ARTHUR GINZEL

THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

COLLEGE OF ENGINEERING

UNIVERSITY OF ILLINOIS

PRESENTED JUNE, 1905

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OF Bachelor of Science in Civil Engineering

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NAVIGATION CANALS OF EUROPE.

INTRODUCTION.

The building of the Panama Canal has aroused a general interest in transportation canals, and any information concerning artificial waterways now in use is welcomed by both the laity and the engineering profession. The experience gained by the success or failure of the great projects of the past, is the basis upon which the methods and operations of this new enterprise will be founded. As the largest and by far the greater part of the canals of the world are located in Europe, it was thought that a compilation of data concerning navigation canals in Europe would be of interest and perhaps value.

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CANALS OF ENGLAND

Canal building in England dates from the construction of the Foss Dyke canal in the year 1121, which is still in use. The canals in this country are numerous — many, however, are of small dimensions and of little importance. There are about 4,000 miles of canals now in use in England.

Manchester Canal.

The Manchester canal, the greatest in England, was built by the merchants of Manchester to avoid the cost and delay of the transhipment of goods at Liverpool.

In 1882 a plan for the construction of a canal with terminus on the Mersey estuary was discussed, but Parliamentary opposition and

the objections of the Mersey Docks and Harbor Board compelled the promoters to change their plans. Work was begun on the canal in 1887 and the canal was in operation throughout on January 1, 1894.

The canal is excavated throughout its whole length of 35½ miles to a minimum bottom width of 120 feet and to an average of 170 feet at the water-level. The width is increased considerably at the numerous lakes used by the canal, and vessels may be turned there if necessary. The width is large enough for large steamers to pass each other on any part of the canal. The minimum depth is 26 feet.

There are three entrance locks at Eastham, the dimensions of which are respectively 600 feet by 80 feet, 350 feet by 50 feet, and 150 feet by 30 feet. Four other sets

between Eastham and Manchester are of similar dimensions, and effect a rise of 60 feet and 6 inches, thus giving an average rise for the locks of 15 feet 1½ inches. All of the locks are worked by hydraulic power. Sills for all the locks are placed 28 feet below water-level to allow for future deepening.

Extensive docks have been constructed at Manchester, and at Warrington there is one covering 23 acres. The masonry, both brick and stone, used in the locks, basins, piers, and retaining walls, is of the best quality both in material and workmanship. The total amount of masonry used was from 175,000 to 220,000 cubic yards.

The deepest cutting is near Runcorn where for a short distance, it is 60 feet. The largest prism cut is at Litchford, where for a

distance of 1½ miles the depth averages 55 feet. The slopes of the excavation vary with the nature of the soil from 1 to 1 to 2 to 1, lock excavations being nearly vertical. The total amount of excavation was 53,000,000 cubic yards of which 2,000,000 cubic yards was sandstone. The waste material was used in filling up the bends in the river Mersey and also for raising the low-lands in that district. Many railways and highways were raised at a great cost in order to give a clear headway of 75 feet for vessels. The Bridgewater canal was carried across the Manchester by means of the Barton Swing Aqueduct, a long iron caisson resting on a pivot pier.

The total cost of the canal was $75,000,000, the excess over the estimated cost of $46,000,000 being due to the extraordinary cost of the

right of way and troublesome opposition.

Leeds and Liverpool Canal

The Leeds and Liverpool canal connects the Irish Sea at Liverpool with the German Ocean at Hull. The construction was begun in 1770, and completed in 1816 at a cost of $5,800,000. It is the longest canal in Great Britain, and up to the building of the Manchester, the most important one.

The canal is 127 miles long with a bottom width of 16 feet and a depth of 5½ feet. At the town of Foulridge there is a tunnel about 5000 feet long, 18 feet high and 17 feet wide. There are 91 locks of an average length of 70 feet, overcoming a difference of elevation of 845 feet. The canal is carried across seven waterways by means of

aqueducts.

Aire and Calder Canal

The Aire and Calder canal forms a communication between Lancashire, Yorkshire and the ports of Goole and Hull. By means of this canal continuous navigation is afforded between the eastern and western coasts.

This canal really consists of several distinct divisions or sections. The Leeds and Goole canal, 36 miles long with 10 locks overcoming a difference of level of 65 feet, 3 inches; the Wakefield canal, 12 ½ miles long with 4 locks overcoming a diff- of elevation of 36 feet 2 inches; and the Barnsley canal, 15 miles long with 15 locks and a fall of 106 feet. Besides these canals, there is a branch from Knottingley

to Goole, 18½ miles long, begun in 1820 and completed in 1826 at a cost of $700,000. This branch is 40 feet wide at the bottom and is 7 feet deep. Three locks overcome the difference of elevation of 28¾ feet.

The dimensions of the main line of the Aire and Calder Canal are: bottom width, 25 feet and depth, 10 feet.

Calder and Hebble Canal.

The Calder and Hebble Canal consists mainly of river navigation, but it is such an important link in the canal system of England that it should not be omitted.

This canal connects the Aire and Calder canal with the Rochdale canal, joining the former at Falling Lock, below Wakefield Bridge, and the latter at Sowerby near Halifax. The

total length of the canal is 22 miles. There are 28 locks in all, through which there is a total fall of 196 feet 6 inches. A large portion of the line consists of river channel, but there are many cuts made throughout the course to shorten distances and avoid obstacles.

Shropshire Union Canals.

The Shropshire Union Canals form a short and convenient route between the Mersey river and the iron industries of Birmingham and Staffordshire. The total length of these canals is 206 miles, and the depth varies between 3 and 5 feet. The principal canals of this system are given below.

The Birmingham and Liverpool canal extends from Autherly to Nantwich, where it joins the Chester Canal. It was begun in 1828 and completed in 1835. The total length of the canals is

53 miles. The bottom width is 16 feet, the top width, 40 feet and the depth, 5 feet.

The Chester canal, from the river Dee at Chester to Nantwich, is 20 miles long and was begun in 1772 and completed in 1776. There is considerable local traffic on this canal, besides that received from the large iron industries of South Staffordshire.

The Ellesmere canal extends from Correghofa in Montgomeryshire, where it joins the Montgomeryshire canal, to Hurleston in Cheshire, where it joins the Chester canal. There is a branch from the river Dee at Chester, to the River Mersey at Ellesmere Port. The main portion of the canal was begun in 1793 and completed in 1795. The total distance covered is 86 miles.

The Montgomeryshire canals extend from Correghofa to Newtown in Montgomeryshire. The total length, including many branches, is 25 miles.

The Shrewsbury canal extends from Wombridge to Shrewsbury in Shropshire. It was begun in 1793 and completed in 1797. The total length is 22 miles.

Regents Canal.

The Regents Canal extends from London to Paddington where it joins the Grand Junction canal. The canal was begun in 1812 and completed in 1820. The total length of the canal is 10½ miles. The bottom width is 16 feet and the depth 5 feet. The traffic consists mainly of coal and building material.

Grand Junction Canal.

The Grand Junction canal extends from Runcorn on the Mersey river, to Wilden Ferry on the Trent river. The canal was begun in 1766 and completed in 1777. The total length of the canal is 96 miles, 30 miles which consists of canalized riv-

ers. The bottom width is 18 feet, the top width 31 feet, and the depth 5½ feet. There is a tunnel 8,664 feet long, 16 feet high and 14 feet wide on this canal.

Surrey Canal.

The Surrey canal is located in the city of London and is 4 miles long. The surface width is 58 feet, the bottom width 52 feet. There is one lock with a lift of 3 feet and a length of 120 feet. The depth of the canal is 5 feet.

Other English Canals.

There are many other canals which deserve mention, but only those of particular interest will be given below.

The Foss Dyke canal is the oldest in England. It was built in 1121 and has been widened and

improved considerably since that time. The bottom width is now 45 feet and the depth, 6 feet. The total length is 11 miles.

The River Weaver navigation is 20 miles long. The depth is 7 feet and the canal will allow the passage of 100-ton vessels. The locks are in pairs and are 220 feet long, 42 feet wide and 15 feet deep. At Anderton was built the first hydraulic lift lock. The lift is 50 feet, 4 inches, the troughs are 75 feet by 15 feet, and the depth, 5 feet.

The Severn navigation is an important link in the chain of navigation between the ports of the Bristol Channel and the Midland districts. It has a depth of 10 feet and accomodates vessels of 300 or 400 tons capacity.

The Exeter canal was the first canal built in Great Britain for the purpose of allowing sea-going vessels to pass to an inland port. The depth of the canal is 15 feet and the

length is 3 miles.

The Gloucester and Berkeley canal was completed in 1827 and is 16 ½ miles long and 18 feet deep.

Other canals of considerable length are: the Oxford canal, 24 miles long; the Coventry canal, 22 ½ miles long; and the North Stafford canal, 67 miles long.

CANALS OF IRELAND.

There are 708 miles of improved navigation in Ireland, 300 miles of which are canals.

Grand Canal.

The Grand canal extends from Dublin westward to the Shannon river, and proceeds on the opposite side of this river to Ballinasloe. It has many branches which, together with the main portion,

brings the total mileage up to 164 miles. The canal was begun in 1753 and completed in 1800. The bottom width is 24 feet and the depth is 6 feet. The locks are 60 feet long, 13 feet wide, and have a lift of 5 feet. The entire work cost # 9,700,000 including the many branches.

Royal Canal.

The Royal canal extends in a northeasterly direction from Dublin to Cloondara on the Shannon river, with a branch to Longford. The canal was begun in 1789 and completed in 1813. The total length of the canal is 96 miles. The bottom width is 24 feet and the depth, 6 feet. The locks have a lift of 5 feet and are 70 feet long and 13 feet wide. The total cost was, including branches, # 9,215,000.

Lagan Canal.

The Lagan canal extends from Belfast to Lough Neagh, a distance of 26 miles. The bottom width is 15 feet, and the depth, 6 feet. There are 26 locks on the canal. The greater portion of this waterway is along the channel of the Lagan river.

Ulster Canal.

The Ulster canal extends from Lough Neagh to Lough Erne. It is 44 miles long with a bottom width of 13 feet and a depth of 5 feet. There are 26 locks on the canal.

CANALS OF SCOTLAND.

There are only few canals in Scotland, but among these few will be found some of large

dimensions and of considerable importance.

Caledonian Canal.

The Caledonian Canal connects Oben on the west coast with Inverness on the east coast, and is by far the most important canal in Scotland. The northeastern portion of the canal is through the Moray Firth for a distance of 23 miles; the southeastern end is through the Lakes Eil and Linnhe for a distance of 32 miles; the centre portion is 60 ½ miles long, 37 ½ miles of which extend through the lakes Ness, Oich and Lochy. The canal proper is but 22 miles long. Construction was begun in 1805 and completed in 1813 after many difficulties and long delays. The work was under the direction of Thomas Telford and cost £6,500,000. The canal has a bottom width of 40 feet and a depth of 20 feet.

There are 27 locks including the tide locks, and their dimensions are: 180 feet long and 40 feet wide. The construction of this canal has shortened the distance between eastern and western ports, several hundred miles. The canal, however, has never been a financial success.

Forth and Clyde Canal.

The Forth and Clyde canal forms artificial communication between the Firth of Forth and the Firth of Clyde. At the eastern end of the canal, it joins the Union Canal at Port Downie. The construction was begun in 1768 and completed in 1790 at a cost of $1,650,000. The total length of the canal is 38 1/4 miles. The surface width is 56 feet, the bottom width 27 feet, and the depth 10 feet. There are 39 locks on the canal, each 74 feet long and 20 feet broad. The lift at each lock is 8 feet. The

canal passes over 10 aqueducts, the largest of which is 83 feet high spanning a valley 400 feet wide

Crinan Canal.

The Crinan canal is built across the peninsula of Kyntire and was constructed to save a distance of 70 miles around the Mull of Kantyre, which passage, ships were compelled to make in going from Loch Gilp to the Atlantic Ocean. It was begun in 1793 and completed in 1801.

The canal is 9 miles long; the bottom width is 24 feet, and the depth 12 feet. There are 15 locks in all, the largest of which are 108 feet long and 21 feet wide. The canal is not a paying enterprise.

Union Canal.

The Union canal extends from Edinburg to a junc-

tion with the Forth and Clyde canal at Port Downie. It was begun in 1817 and completed in 1822. The total length is 31½ miles; the top width is 37 feet, the bottom width 20 feet and the depth, 5 feet. There are 11 locks on the canal and the rise or fall at each lock is 10 feet, 3 inches. There is one tunnel 696 yards long, 15 feet high and 13 feet wide.

Monkland Canal.

The Monkland canal, now a portion of the Forth-Clyde canal, forms an artificial communication between the city of Glasgow and the district of Monkland. The canal has four branches extending into the iron industries of this section. The total length of the canal is 18 miles. The top width is 35 feet, the bottom width 24 feet and the depth 5½ feet. The canal was made part of the Forth-Clyde canal in 1846.

CANALS OF WALES

Glamorganshire Canal.

The Glamorganshire canal and its branches, is the largest and most important canal system in Wales. The total length of the canal is 20 ½ miles. The locks can accomodate vessels of 9 feet beam and 60 feet long. The depth of the canal is 5 feet.

Other Welsh Canals.

The other canals of Wales are: the Brecon and Abergavenny, 33 miles long; the Monmouthshire Canals, 20 miles long; the Neath canal, 14 miles long, and the Swansea canal, 17 miles long. These canals are 30 feet wide at the surface, 14 feet wide at the bottom, and their depth varies from 3 to 5 feet.

CANALS OF BELGIUM

Belgium has 1360 miles of navigable waterways, making a proportion of one mile of canal to every eight square miles of territory. This unusually large proportion of canals is due to the exceptionally great facilities which the natural waterways offer for safe navigation. A few of the most important canals will be discussed somewhat fully while those of small commercial value will be given but little space.

Ghent-Ternhäusen Canal.

The Ghent-Ternhäusen canal connects the great manufacturing city of Ghent with the sea and is the most important of the Belgian canals. An outlet for Ghent to the sea was discussed as

early as the thirteenth century, and since then numerous attempts have been made to construct the canal. Shifting sands and other difficulties long prevented a satisfactory conclusion of the work, but in 1823, under the auspices of the government, the canal was completed and opened to traffic

The canal is 22 miles long and its present cross-section is: bottom width, 55 feet 3 inches, surface width, 182 feet and depth, 21 feet. The canal will be enlarged to have a bottom width of 78 feet, surface width of 212 feet, and a depth of 28½ feet.

There are four locks on the canal — two at Sas de Gand and two at Terneuzen. The La Louvière hydraulic lift lock, by which boats are raised 50½ feet, was the largest of its kind when built. A new lock will be built at Sas de Gand with a length of 650 feet,

a breadth of 84½ feet, and a depth of 30 feet 10 inches. There will also be a new lock at Terhäusen with a length of 455 feet, a width of 58½ feet, and a depth of 27 feet 2 inches.

Willebroeck Canal.

The Willebroeck canal extends from Brussels to the river Rupel and is the oldest of the Belgian canals. It was begun in 1550, and was completed in 1561. The canal was then only 33 feet wide and had a depth of 6½ feet. In 1829 to 1835 the canal was enlarged to its present dimensions, which are: bottom width 24½ feet and depth 10½ feet. The depth will finally be 21 feet, the width at bottom 58½ feet, and the width at the waterlevel 130 feet.

According to the plan for improvements now under way, there will be 4 locks 371 feet long, 59 feet wide and 21 feet deep. The locks will be

supplied with water from the river Leine. The course of the canal will be changed considerably under the new enlargements and many sharp curves will be removed.

Ghent Ostend Canal.

The Ghent-Ostend canal extends from Ghent to Bruges and from Bruges to Ostend, connecting with the North Sea. The part from Bruges to Ostend was completed in 1822, and the whole work was finished in 1825.

The canal is 42 miles long and is at present navigable by barges and ships with a draught of 6 feet 6 inches on the Ghent-Bruges portion and 14 feet on the Bruges-Ostend section. The bottom width is 65 feet and the width at water-level is 204 feet with side slopes of 1 to 3. The canal will enlarged however, and will be 25 feet deep up to a point 2½ miles of Ostend—

the rest of the canal will be large enough to permit the passage of 2000 ton barges. There are five sets of locks on the canal with an average length of 65 feet and an average depth of 10 feet.

Charleroi Canal.

The Charleroi canal extends from Charleroi to Brussels uniting at the latter place with the Willebroeck canal. The canal was begun in 1832, and was finished in 1839.

There are 55 locks which vary in length from 620 to 130 feet and have an average width of 33 feet. The canal will shortly be improved to accommodate 400-ton vessels. This canal has numerous branches extending to the coal fields in that territory, and its traffic consists mainly of products from these fields.

Canal de Junction de la Meuse á l'Escaut.

The Canal de la Junction de la Meuse á l'Escaut extends from Antwerp to Bocholt, the point of confluence with the Maestricht-Bois de Luc canal. Work on the canal was begun in 1843 and the main portion was completed in 1844, while the branches were built between 1846 and 1856. Its branches are: one toward Hasselt, with a length of 24½ miles, one toward Beverloo, with a length of 95 miles and a third toward Turnhout, 15 miles long.

The canal is 54 miles long; its depth is 6 feet 6 inches and its bottom width 32½ feet. The present capacity of the barges using the canal is 350 tons. The improvements now being made will bring the depth to 8 feet 2 inches and the bottom width to 76½ feet, allowing the passage of vessels of 1000 tons capacity.

Meuse-Sheldt Canal.

The Meuse-Sheldt canal consists of three sections. The first section is from Bocholt at the junction of the Meuse and the Sheldt to Pierre Bleue. The second section is from Pierre Bleue to Herenthals, where the junction with the Scheldt is made by means of the canalized river Petite Néthe. The third section is from Pierre Bleue to Hasselt making a junction with the river Demer. The first section was completed in 1846 and the third in 1856. The total length of the canal is 54 miles. The width is 33 feet and the depth, 7 feet, with side slopes of 1½ to 1.

Turnhout-Antwerp Canal.

The Turnhout-Antwerp canal is an extension of the canal from Pierre Bleue to Turnhout. It follows the line of the River Scheldt to St. Leon-

hard where it turns south and joins the canal of the junction between the Meuse and the Sholdt, a few miles from Antwerp. The portion as far as St. Leonhard was completed in 1874.

The canal is 23 miles long and has a depth of 7 feet and a width of 33 feet. The chief benefit from this canal was obtained by the city of Turnhout, since it stimulated manufactories in that city to a great extent and increased its importance commercially.

Other Belgian Canals.

The Blaton Canal extends from Blaton to Ath. It is 13½ miles long, with a bottom width of 36 feet and a depth of 7 feet. There are 21 locks whose average length is 134 feet and average depth is 6 feet.

The Pommeroeul and Antoing canal extends from Pommeroeul to Antoing, connecting

the canal of Mons with the Escaut. It was finished in 1826 and was purchased by the government in 1828. The total length of the canal is 15½ miles. The width is 20 feet and the depth is 7 feet. There are 13 locks with an average length of 128 feet and average width of 17 feet, with a depth of 6½ feet.

The Liege-Maestricht canal extends from the river Meuse in Liege Liege, to Maestricht and again enters the Meuse. It was commenced in 1845 and completed in 1850. Its length is 16 miles.

The Maestricht-Bois de Luc canal is a prolongation of the Liege-Maestricht canal, and was begun in 1823 and completed in 1826. It is 28 miles long.

The canal from Plasschendaele to Nieuport leaves the canal from Bruges to Ostend and unites at Nieuport with the Yser river and with the

Nieuport-Furnes Canal. It is 13 miles long, and its branches are: the Oudenbourg, the Moerdyck, Ghistella and Bourgogne canals, aggregating 7½ miles.

There are numerous other canals of small dimensions in Belgium which are connecting links in the admirable system, but their importance does not deserve special mention.

CANALS OF FRANCE.

The canals of France are very numerous, this country having spent more money for artificial waterways than any other nation. The chief commercial centres are connected by an excellent system of water communication, the total length of which is 10,500 miles, 3000 miles being artificial. The chief canals of France will be discussed here, but no attempt will be made to give historical data concerning them.

Canal du Midi.

The Canal du Midi connects the river Garonne and the Bay of Biscay with the Mediterranean Sea, and is the earliest instance of a canal built to join two seas. Work was begun on the canal in 1666 and completed 14 years after at a cost of £2,100,000. The construction of this canal relieved vessels of the necessity of making the long journey through the Straits of Gibraltar, when trading between eastern and western ports.

The canal is 125 miles long; the breadth is 30 feet and the depth, 6 feet 7 inches. Nearly one sixth of the canal is excavated through mountains, the rock cutting at Mal Pas being 30 feet deep. There are 99 locks of an average lift of 8 feet, the dimensions of which are: length 91 feet, breadth 19 feet and depth 5 feet. The water supply is received from the rivers Orb, Herault and a tributary to the Aude, and at its

summit level, from reservoirs at Lampay and at St. Séréol. The canal was formerly of considerable importance, but since the introduction of railroads, traffic on it is nearly suspended.

Lens la Deule Canal.

The Lens la Deule canal was constructed to give transportation for the coal mined in the vicinity of the city of Lens. The canal was begun in 1885 and completed the next year. The total length of the canal is about 40 miles; the least bottom width is 17 3/4 feet, and the depth, 7 1/4 feet. There are 4 locks having an average lift of 10 feet. The dimensions of these locks are: width 17 feet, length, 126 1/3 feet and depth 8 1/4 feet. The total cost of the canal $360,000.

Briare Canal.

The Briare canal forms a communication be-

tween the river Loire and the river Loing, a branch of the Seine, and is the first French canal to use locks. It was begun in 1605 and completed in 1642. The total length of the canal is 37 miles; the width is 18 feet and the minimum depth 6½ feet. There are 43 locks on the canal, each of the following dimensions: length 108 feet, width 17 feet, and a depth of 9 feet.

Marne-Rhine Canal

The Marne-Rhine canal commences by a junction with the Upper Marne canal at Vitry le Français and terminates by a junction with the river Ill and the Rhine canal near Strasburg. The canal was begun in 1838 and completed in 1853. The total length of the canal is 193 miles; the bottom width is 32 feet 10 inches and the depth 6½ feet with side slopes of 1½ to 1. There are 177 locks on the canal with a mean rise of 8.6 feet. Five tunnels are used, which

have a total length of 5½ miles.

St. Louis Canal.

The St. Louis canal extends from the Rhone river to the Mediterranean Sea at the Bay of Foz, and was built to avoid the bar at the mouth of the Rhone. It was begun in 1863 and completed in 1873. The canal is over two miles long; it has a depth of 19½ feet, a bottom width of 100 feet and surface width of 207 feet. It is separated from the Rhone river by a lock 24½ feet deep, 72 feet wide, and 525 feet long.

Canal of Tancarville.

The canal of Tancarville extends from Havre to Tancarville on the Seine and was built for the purpose of avoiding the danger to river craft in navigating the lower Seine. It was finished and opened to traffic in July 1887. The length of

the canal is 18 miles, the depth is 19½ feet and the width 52 feet. At Havre and Tancarville are large receiving basins locked through two double gates, the length of each being 750 feet and 1900 feet respectively. The soil encountered was mostly alluvial and the cutting presented little difficulty. The total cost of the canal was $4,650,000.

Canal from Caen to the Sea.

The canal from Caen to the Sea extends from Caen on the river Orne to Ouestreham on the Atlantic, and was built to give sea-going vessels access to the port of Caen. The canal was begun in 1843 and completed in 1857 at a cost of $1,940,000. It is 9⅝ miles long; the depth is 17 feet, the top width 88 feet, and bottom width 32 feet. The surface is level throughout with locks at each end.

Canal from Nantes to Brest.

The canal from Nantes to Brest establishes navigation between the rivers Loire and Vilaine and was completed in 1838. The total length of the canal is 270 miles. There are two sections; the first extends from Nantes to the city of Redon, a distance of 69 miles, the second extending along the river bed for 15 miles, then leaving the river and continuing to Brest, forming junctions with numerous small rivers. The surface width is 50 feet and the depth, 5 feet. There are 55 locks in use on the entire canal.

Other French Canals.

The French Assembly in 1879 adopted a law requiring all the principal canals of France to have a depth of at least 2 meters (6.56 feet) with locks not less than 38 meters 50 long and 5 meters 20 wide (125.47

feet by 11.06 feet). The canals not already mentioned which conform to these requirements are: the Aulize, 21 miles long in Southern France, the canal du Centre, 72 miles long, the Canal Roanne à Dijon, 35 miles long, the canal du Berry, 154 miles long, in central France. The canal de Bourgogne 151 miles long and the Canal d' Orleans 41 miles long also come up to these requirements.

CANALS OF HOLLAND.

Holland has an extensive system of canals which cross the country in all directions, forming a network of artificial waterways over the entire land. Many of these canals are of little importance, and only the two most important will be discussed here. These two are: the Amsterdam canal and the North Holland canal.

Amsterdam Canal.

The Amsterdam canal was built to give the city of Amsterdam access from the North Sea. Previously the only way of reaching the city from the sea was through the North Holland Canal, fifty miles long and of small section.

The canal was begun in 1864 by the Amsterdam Ship Canal Company, and is 16 miles long. The orignal dimensions were: bottom width 88.73 feet, top width 175 feet through the sand hills, and 360 feet through the lakes; the depth throughout was 23 feet. In 1877 to 1883, the depth was changed to 25¼ feet, and the bottom width increased; and in 1889 the present dimensions were obtained, i.e. depth 29½ feet, and bottom width 82 feet. It is proposed now to make the depth 32.1 feet, and the bottom width 164 feet.

The Zuyder Zee is shut off by means of an

embankment over 4000 feet long in which are placed three locks. The largest is 315 feet long and 59 feet wide. At this embankment it was necessary to install a pumping plant to pump out the drainage-water from the canal, the amount taken out ranging from 5,000,000 to 6,000,000 cubic yards in 24 hours, during heavy rains. On the North Sea there are two tidal locks, 293 feet x 59 feet, and 229 feet by 39½ feet, respectively, with 23½ feet over the sills of the large one, and 14 feet over the smaller one. Because of the increased traffic a much larger lock had to be built which was completed in 1895. It is 740 feet long, 82 feet wide, and 30 feet above the sills.

The harbor works to protect the entrance to the canal were very extensive. Two converging jetties built of concrete, were each one mile in length. There was also placed as a wave-breaker,

a line of concrete blocks, 3900 feet between pier-heads. The enclosed area is 247 acres, and through it a channel was dredged to deep water. This channel has a bottom width of 490 feet and a depth of 28½ feet. The maintenance of this channel requires the removal of 6,500,000 cubic yards per annum, which is done by sand-pump dredges.

In 1882 the canal was ceded to the state. The origonal cost of the work was about $15,000,000, and required the removal of 21,000,000 cubic yards of excavation. There are no tolls charged on the canal since it is owned by the state.

North Holland Canal.

The North Holland Canal was built for the purpose of avoiding the shoals at the junction of Lake Y and the Zuyder Zee, and thus affording a safe

passage from Amsterdam to the Lea. Before 1819 vessels were compelled to unload part of their cargo at these shoals and were consequently often detained for several weeks. The canal extends from Lake Y, nearly opposite Amsterdam, to the harbor of Nieuwdiep on Texel Roads. The construction of this waterway was begun in 1819 and completed in 1825.

The canal is 50½ miles long, its depth is 20 feet 9 inches, the bottom width 30 feet and top width 124½ feet. This is a tide-level canal with two tidal locks at each end to exclude the high tides from the canal. These locks are double, having two chambers, 237 feet by 51 feet and 82 feet by 18½ feet, respectively.

The canal was of great benefit to Amsterdam until the construction of the Amsterdam canal, whose greater importance and convenience threw the North Holland canal more or less into disuse.

CANALS OF DENMARK.

There are only two important canals in Denmark namely, the Odense canal and Frederick the Seventh canal.

Odense Canal.

The Odense Canal connects the town of Odense in the island of Fynen with the entrance to the Odense Firth. The canal is of considerable benefit to agricultural shippers on the island and it also avoids transhipment of goods at the Firth. The canal was begun in 1796 and completed in 1803. It has been deepened from time to time, and at present is 15 feet deep with a minimum width of 35 feet. The total length, between mouths of harbors at each extremity is five miles.

Frederick the Seventh Canal.

The Frederick the Seventh canal is built between the deeper parts of the Limefjord in Jutland, to the east and to the west respectively, of Logstör. The canal was built to avoid the shoals in the firth west of Logstör. The canal was completed in 1861. Its depth is 9 feet, its minimum width 75 feet and its total length, 2.9 miles.

CANALS OF GERMANY.

The canals of Germany have been built with great care since the transportation has been under governmental control. Although not possessed of the natural resources of some other European countries, Germany has now over 1500 miles of canals. Most of the large rivers have been canalized.

Kaiser Wilhelm Canal.

The project for a short safe passage between the Baltic and North Seas was under consideration for several centuries, but only recently was anything material accomplished. The object was partly realized in 1777-78 by the construction of the Eider Canal; but this proved inadequate, since only vessels of 120 tons capacity could use it. When Kiel became the naval arsenal of Germany, it became necessary to have a short reliable passage between the two seas in German territory. Accordingly a project was formed in 1864, but the wars of 1866-70 prevented its realization. The construction of the canal was approved in 1886, the work begun in 1887, and was completed in 1895.

The length of the canal is 61⅓ miles, the bottom width, 72 feet, and the minimum depth

29½ feet. Its minimum width at the water surface is 216 feet, and the maximum, 283 feet. There is a narrow berm below water level in deep cuttings, and a wider one on low ground. The deepest cut is 108 feet, where the canal crosses the ridge between the rivers Eider and Zehe. The total quantity of excavation was 105,000,000 cubic yards. The canal has embankments on both sides in low ground, and the slope is protected by stone paving from 6½ feet below the water to 3¼ feet above. The side slopes are 3 to 1 at the bottom and 2 to 1 higher up.

This is a sea-level canal with regulating locks at each end. The Baltic is practically a tideless sea, but the North Sea has a maximum range of 27½ feet. Two locks, side by side, allow out-going and incoming vessels to pass at the same time. The lock chambers are 492 feet long and 82 feet wide. The sills are 33⅔ feet below the normal

low water level. The canal is lighted by electric lights placed 800 feet apart.

The passage through is limited to 10 to 12 hours to prevent to much washing of the banks. The cost of the canal was about $40,000,000.

Dortmund-Ems Canal.

The Dortmund-Ems canal, extending from Dortmund to Emden, is the culmination of a project started two centuries ago, and is one of the largest canals in Europe. The chief object of the building of this canal, was to develop the Westphalian coal fields. The construction was begun in 1889 and completed in 1899 at a cost of $17,360,000.

The canal is 173 miles long — 115 miles of canal proper, 38 miles of canalized river and 20 miles of unimproved river. Starting at Dortmund the canal runs northwest to Meckinghoven, north of Henrichs-

burg where it meets a branch from Herne. On leaving Henrichsburg, it runs northeast to Münster where boats are lowered by means of two locks. From here the canal extends to Emden by way of the Ems river.

The canal has a depth of 8.2 feet, a bottom width of 59 feet and a surface width of 98.4 feet. The side slopes are 1 to 3 for 3½ feet above water to 3½ feet below, the rest being a slope of 1 to 2. These slopes are protected from the waves by a paving of stone or concrete.

There are 22 locks on the canal varying from 219 feet to 541 feet in length. At Henrichsburg there is a huge lift lock, which, at the time of its building was the largest in the world. The water of this lock is suspended in a bridge-like structure, supported by trestle work and resting on five floats, which rise and fall in water-filled wells. The length of the chamber is 230 feet, the width, 28 feet and the depth, 8¼ feet.

Other German Canals.

The Lübeck canal begins at Lauenberg on the Elbe and ends at Lübeck on the Trave River. The construction was completed in 1900 at a cost of $5,500,000. The total length of the canal is 42 miles, of which 16 miles are taken up in curves. The least depth is 6 feet 6 inches and the bottom width is 72 feet. The canal will finally be 8 feet deep with a bottom width of 89 feet 6 inches.

The Oder-Spree canal is 54½ miles long and cost about $3,000,000. The depth is 6½ feet, the surface width 76 feet and the bottom width 46 feet. The locks are 180 feet long, 28 feet wide and 8 feet 3 inches deep above sills.

The Holstein (Eider) canal extends from Holtenau, near Kiel, to the North Sea, a distance of 25 miles. It was begun in 1777 and completed in 1785. The surface width is 100 feet, the bottom width, 68 feet, and the depth, 11 feet.

The Rhine-Marne Canal was described under French canals.

Besides these there are the Friederich Wilhelm canal 15 miles long, uniting the Oder and the Sprée; the Finow canal 30 miles long uniting the Oder and the Havel; the Plauer canal uniting the Havel and the Elbe rivers, 21 miles long; the Ruppine Canal, uniting the Rhine and the Havel, 24 miles long; and the Bromberger canal uniting the Oder and the Weishel, 17½ miles long.

CANALS OF SWEDEN.

The canals of Sweden have not attracted any particular attention nevertheless they are by no means unimportant since there are several of them which are of considerable extent and cost.

Trollhättan Canal.

The Trollhättan canal was built for the purpose of avoiding the rapids in the Göta River near the town of Trollhättan. By means of the canal, communication between the North Sea and Lake Venern is established. The canal was completed in 1800 and rebuilt from 1836 to 1844 at a cost of $600,000.

The total length of this waterway is 22 miles; the minimum bottom width is 23½ feet and the depth 12 feet 8 inches. The difference of elevation is 142 feet,

overcome in 16 locks all built of granite. The opening of this canal made Gothenburg, situated at the mouth of the Göta river, the leading commercial center of Sweden.

Göta Canal.

The Göta canal establishes communication between Lake Venern and the Baltic Sea and is one of the most important of the Swedish canals. It was begun in the year 1811 and completed in 1832.

The artificial portion of the canal is 54 miles long and its total length is 115 miles. The depth is 9.8 feet, the bottom width, 49.5 feet and the surface width 85 feet. There are 58 locks each 121.3 feet long and 22.9 feet wide. A great deal of granite was encountered in the excavation of the canal which changed the course considerably. The banks are paved a few feet above and a few feet below the water and ledges are planted on the banks to diminish the effect of the washing waves.

Dalsland Canal.

The Dalsland canal connects Lake Venern with a number of narrow lakes near the borders of Norway, thus affording communication between the town of Dalsland and the outer world. The canal was begun in 1864 and completed in 1868. It is 48 miles long with a bottom width of 13 feet and a depth of 5½ feet. The difference of elevation is 192 feet 6 inches overcome in 25 locks which are 98 feet 6 inches long and 13 feet 8 inches wide with a depth of 5 feet.

Kinda Canal

The Kinda Canal connects a chain of lakes in the southeastern part of Sweden with the Göta Canal and is 49½ miles long, of which 22 miles is artificial. There are 15 locks overcoming a difference of elevation of 171 feet. The locks are 90 feet 6 inches by 184 feet 4 inches and 4 feet 10½ inches deep. The canal was completed in 1871 at a cost of $350,000.

Other Swedish Canals.

The Strömsholm canal extends from the Northern provinces to Lake Mälaren and Stockholm and is 68 miles long - 7½ miles of which is artificial and of a depth of 7½ feet. There are 25 locks in use.

The Södertelge canal, joining Lake Mälaren with the Baltic Sea is 2 miles long 30 feet wide at bottom and 60 feet wide at surface with a depth of 12 feet throughout. It is cut through sand hills some of them 100 feet high.

CANALS OF RUSSIA.

The canals of Russia were built chiefly for the purpose of uniting navigable rivers. Canal building was begun under Peter the Great, who planned the scheme of uniting the Caspian and Baltic Seas with the Black sea by joining the rivers Volga and Don. Many of the canals have been abandoned in the last few years.

St. Petersburg-Kronstadt Canal.

The St. Petersburg-Kronstadt Canal extends from the Neva at St. Petersburg to the city of Kronstadt. The canal was begun in 1877 and completed in 1884 and its chief purpose was to convert the city of St. Petersburg into a port. Before the construction of this canal, the large vessels were prevented from reaching St. Petersburg because of the bar in the river Neva.

The canal is 18½ miles long; its least bottom width is 207 feet, and its depth throughout is 22 feet. There is a continuous embankment on the side of the Gulf of Finland, but for the last 10 miles a channel 275 feet wide was dredged through the gulf which has a depth there of from 12 to 15 feet. The total excavation was 8,700,000 cubic yards of which 5,300,000 cubic yards were excavated between the years 1877 and 1882, the average number of cubic yards per

day being 8480. The canal has proven a great benefit to the city of St. Petersburg, since the great bulk of the trade formerly received by Kronstadt, is almost entirely transferred to the former city.

Hyegra and Kovja Canal.

The Hyegra and Kovja canal joins the rivers Hyegra and Kovja. The construction was completed in 1886 and 20,000 laborers were employed in the undertaking. The canal is 15 miles long and is 70 feet wide and 7 feet deep. The quantity of excavation was 2,000,000 cubic yards, some of the cuttings being 30 feet deep.

Canal Systems.

The three great canal systems of Russia are known as the Vishnivoldsk, Tchekvinsky and Marie systems respectively. They connect the navigable streams of the empire and furnish communication between the commercial centres. The traffic on these canals has, however, been

greatly decreased since the advent of railroads.

CANALS OF FINLAND.

Saima Canal.

The Saima canal is the most important in Finland. It connects several inland lakes with the gulf of Finland at the town of Wiborg. The canal is 35 miles long; the height above sea level is 255 feet and the lowering is effected by means of 28 locks which have a length of 120 feet, a depth of 9 feet and a width of 25 feet. The construction was worked partly through granite and partly through ordinary earth. The work began in 1845 and was completed in 1857 at a cost of $3,600,000.

Pielis elfs Canal.

The Pielis elfs canal is 35 miles long and connects the lakes with the Saigma canal system. The difference of elevation is overcome by ten locks of an

average lift of 6.2 feet. The size of these locks are practically the same as those of the Saima. The cost was #750,000.

Other Finnish Canals.

There are 10 smaller canals in Finland connecting the smaller lakes. The locks of most of these canals are of wood, and the chief articles of transport are lumber and farm produce. Their size is too small for mention here.

CORINTH CANAL.

The Corinth canal, crossing the isthmus of Corinth, was built for the purpose of shortening the distance between ports in the Adriatic Sea and those in the Piraeus. The saving in distance amounts to

more than 130 miles.

The canal was begun in 1882, a Hungarian named Turr having obtained a concession in 1881 for the building of the waterway. The work was completed in 1893 at a cost of $11,000,000, although there were several delays in the work caused by financial failures of the companies building the canal.

The total length of the canal is somewhat less than 4 miles. The bottom width is 72 feet and the depth, 26.5 feet. The side slopes are 2 to 1, and 1 to 1 in soft ground, and 1 to 10 in rock. The ground rises rapidly, so that the cutting averages 190 feet for 2½ miles with a maximum cutting of 287 feet. The total material excavated was 14,260,000 cubic yards. It was found necessary to line the slopes with 216,000 cubic yards of masonry from the bottom of the canal to above the water-line, along 2½ miles of the central portion, great-

by increasing the cost. On the Gulf of Corinth there are two breakwaters 1300 feet long and 1640 feet long respectively, starting from the shore 1150 feet apart and leaving an entrance of 262 feet. On the Gulf of Aegina, a single breakwater was built.

The canal has proved to be a commercial failure, since navigation by large vessels is hindered by the small section and steep sides, making the canal dangerous to shipping. The great advantage of shortening distances to Black Sea ports is more than offset by the physical difficulties encountered; and unfortunately there are no funds at hand to overcome these trouble-some conditions.

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